Spring 5-31-1938

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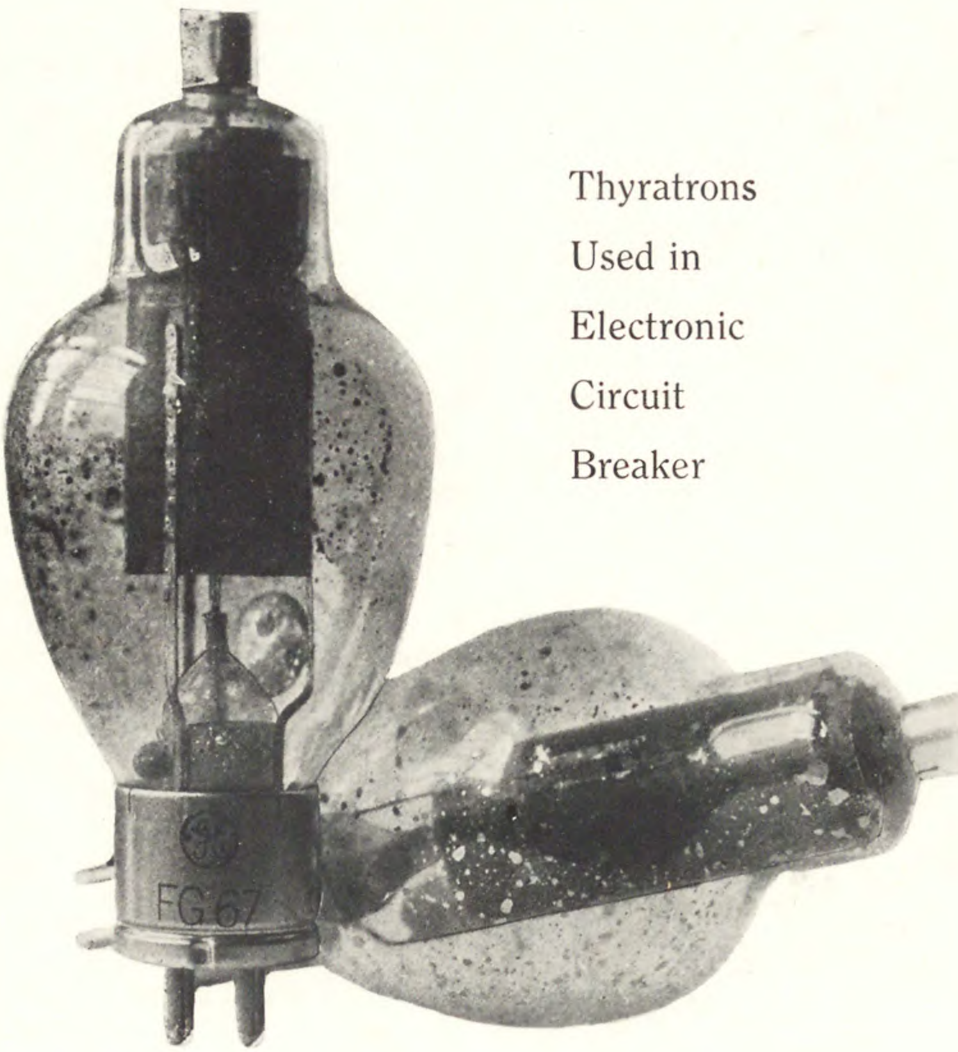
Newark College of Engineering

NEWARK ENGINEERING NOTES . . . . . .



Thyratrons Used in Electronic Circuit Breaker

Vol. I No. 2 May, 1938

THE PRESIDENT'S DIARY

"Selecting Faculty Members" — "Men of Character"
"Brains Are Where We Find Them"—"A Journalistic Opinion"

March 15th

At this time of year educational administrators are busy with the business of filling vacancies on the instructing staff, and each week brings many letters of men young and old who wish to change their connections or to enter upon a teaching career. It is not so strange that in a time of depression many seek what they consider the asylum (or perhaps sanctuary would be a better word) of the halls of learning.

It is strange that so many should want to change. Distant fields are greener. The best fishing is a little further on. The best opportunity is around the corner.

All this is by way of leading to a real question that perhaps is as fundamental as any in an institution of learning. What kind of faculty has it? If the library be "the heart of the University," the faculty is the brain and the will combined.

And how are faculties picked? What do we look for in these men from whom the letters of application come? What is the most important trait in a professor let us say? Academic performance, teaching ability, capacity for original investigation, professional training or professional experience? All of these are important. I remember some twenty-five or more years ago the question was put to me by a very wise and a very successful administrator then the head of perhaps the most influential technical institution in America. A Scotsman he was and an eminent scientist. To him the right answer was, "Character." While I gave the right answer then I must have guessed it. Today I would give the same answer but it would not be a guess.

April 8th

The last entry may seem a bit personal but diaries become a bit personal at times in spite of all you can do, because personal things are closest to us, strike deepest, and therefore last longest. Perhaps it is just as well to be a little personal at times.

But why character? We engineers must define. Character means control and the basis of control is a sense of relative values. What is important and how important is it? And if it is important can we and will we exercise control? A man with character has temptations and desires but he also has control.

So a professor must correctly evaluate and have a keen sense of the relative value of teaching, research, academic training, professional experience and all the rest. And the last word probably is this: Only a man of character is fit to be a leader of young men. This is what a teacher must be.

While it is very gratifying to know that so many of us are in Who's Who in Engineering, it is merely incidental; our first concern is with leading young men. And when they are started right and have themselves under control as it were, we become very much interested in science pure and applied, engineering, original investigation, and all the rest, in their proper places and at the proper time. A sense of value and "Nothing too much." Some sense of ethics, of responsibility, some maturity, properly precedes original investigation.

April 15

One of my educational friends, I know, takes issue with me on the question of where we find brains in America, holding that the better nourished are on the average the brightest. It is a delicate question at best but still I shall maintain, "Brains are where we find them." At least we can say about food that too much is as bad as too little. Witness a one o'clock class in any of our schools. I'm not at all sure that all or even more than half of the courageous and heroic deeds of history have been on a full stomach. I can study better at the other extreme. And many of the great advances of society, like the French Revolution, boiled from the bottom up because of empty stomachs. I wonder if my friend really could find much undernourishment in his school or ours.

April 25th

Showed one of my journalistic friends a copy of NEWARK ENGINEERING NOTES and loudly bewailed the fact that there were so many mistakes in it. He was comforting if not entirely complimentary when he said, "The first issue of anything is full of bugs." I think the publication will make a place for itself and serve the purpose of keeping all of us who have any interest in the Newark Technical School or the Newark College of Engineering a little closer in touch with what Students, Faculty and Alumni are doing. And I find much to my satisfaction that our friends are numerous and loyal.

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CONTENTS

THE PRESIDENT'S DIARY - - - - - - - 2

"ORGANOLITES: ORGANIC BASE-EXCHANGE MATERIALS" - - - - - - - - - - - 4
By Harry Burrell

A HIGH SPEED ELECTRONIC CIRCUIT BREAKER - - 6
By Henry Jasik

FIRST PRIZE TO HENRY JASIK AT STUDENT CONVENTION 7
By Mildred Preen

THE "EASY FORMULAS" IN REINFORCED CONCRETE DESIGN - - - - - - - - - - - 8
By Odd Albert

ALUMNI PERSONALITIES - - - - - - - 10

WHAT OUR READERS SAY - - - - - - 11

PROFESSOR JOFFE'S INTEGRAL - - - - - 11

PORTABLE VIBRATION INSTRUMENTS - - - - 11

FROM THE MAIL BAG - - - - - - - 11

A MESSAGE FROM THE EDITORS - - - - - 11

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From time to time you will receive a copy of the NEWARK ENGINEERING NOTES. In case you like to receive this magazine regularly, the only thing you have to do is to write us and say so. Address your letter to the Editor, Newark Engineering Notes, Newark College of Engineering, Newark, N. J.

"ORGANOLITES: ORGANIC BASE-EXCHANGE MATERIALS"

Condensed from *Industrial and Engineering Chemistry*, for March, 1938

By HARRY BURRELL, *Ellis-Foster Co., Montclair, N. J.*

In 1850, J. Thomas Way was conducting research on fertilizers for the Royal Agricultural Society when he discovered the phenomenon of base exchange. Fifty-six years elapsed before the reaction found commercial application in the use of zeolites for softening water. It has been long known that both organic and inorganic constituents of soil may base exchange, but only very recently have organic counterparts of zeolites been considered for commercial exploitation. It is proposed that base-exchange materials of organic origin be called "organolites."

Besides naturally occurring and artificial humates, synthetic resins have been proposed for water treatment. These resins are of the phenol-aldehyde class, and those prepared from formaldehyde and catechol tannins show some promise. Researches carried out by the author have led to the development of synthetic organic base-exchange materials which possess qualities such as cheapness, high exchange capacities, and resistance to aggressive waters, which indicate that they may be of considerable value industrially. These organolites are prepared by rendering initially water-soluble wood extracts, especially those of the tannin type, insoluble by treatment with concentrated acids—for example, sulphuric acid. They will exchange either sodium or hydrogen ions for calcium or magnesium.

Why such materials exhibit base exchange is not definitely known. In the case of the polyhydric phenol-formaldehyde resins, it is probable that large molecules are built up in the way usual for phenol-formaldehyde condensations to produce substances which are capable of exchanging bases in a manner similar to that of humus or lignin derivatives—that is, through functional phenolic groups.

When tannins are treated with concentrated sulphuric acid, a number of reactions undoubtedly occur simultaneously. Dehydration, oxidation, sulphonation or sulphation, and polymerization all play a part in insolubilization. It may be noticed, incidentally, that this is rather anomalous since sulphonation is a well-known method for rendering organic substances water-soluble. At any rate, the end effect is evidently the formation of molecules, which are of such size as to be water-insoluble and which contain groups such as hydroxyl or sulphonic which are capable of salt formation. These functional groups probably react with cations and hold them until they are released by the mass action effect of the regenerating solution.

Preparation of Materials

The procedure for preparing these materials consists simply in adding the powdered tannin to a concentrated acid such as sulphuric acid, and thoroughly mixing the two. An exothermic reaction ensues, sulphur dioxide is evolved, and a black vesiculated mass is obtained. This is allowed to stand for 30 minutes after the maximum temperature is reached, when it is poured into a large volume of water. The insoluble material is filtered off, dried, ground and screened. The temperature of the reaction and the ratio of acid to tannin must be controlled so that the product will have maximum base-exchange capacity. The effect of these two variables is indicated in Figures 1 and 2. Tannins found to be especially suitable are quebracho and waste hemlock cellulose sulphite liquor; besides sulphuric acid, the acid sludge by-product for petroleum refining yields an interesting product.

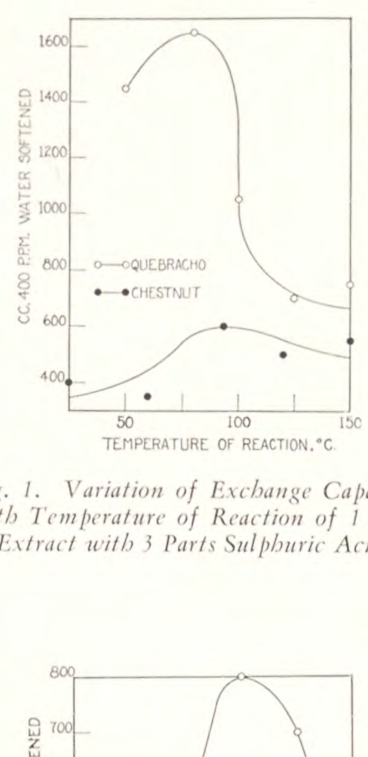


Fig. 1. Variation of Exchange Capacity with Temperature of Reaction of 1 Part Extract with 3 Parts Sulphuric Acid.

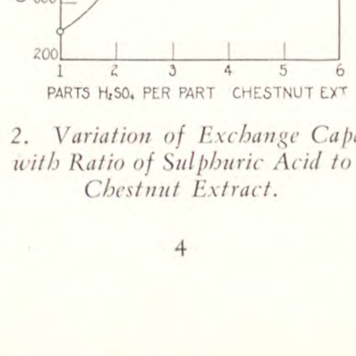


Fig. 2. Variation of Exchange Capacity with Ratio of Sulphuric Acid to Chestnut Extract.

Determination of Base-Exchange Capacity

The apparatus for determining the exchange capacity is shown in Figure 3. Tubes I and II contain 2 x 10 cm. beds of organolite screened through 20 on 40 mesh sieves. With proper setting of stopcock C and the various clamps, either hard water (from bottle A) or brine (from bottle B) may be passed upward or downward through the filter beds. The cycle of operation is backwash, drain, regenerate, wash, and soften. During the softening step, each 100 cc. portion is tested for hardness, and when an effluent containing 5 p.p.m. hardness is obtained, the cycle is repeated. The capacity is calculated from the following formula:

$$E = V \cdot \frac{H}{10^6} \cdot \frac{28{,}320}{B} \cdot \frac{15.43}{1000}$$

$$= 0.000435 \frac{VH}{B}$$

where

E = exchange capacity, kilograins $CaCO_3$ per cu. ft.

V = volume water softened, cc.

H = hardness of water, p.p.m. (400)

B = volume of test bed, cc. (31.4)

Acid Regeneration

An important advantage of organolites over zeolites is that they may be regenerated with an acid whose anion constituent forms a soluble salt with the cation exchanged for the hydrogen ion. There is some evidence that zeolites may be incapable of reversibly exchanging hydrogen ions. Whether or not this is theoretically possible, it cannot be practically realized with zeolites because they are

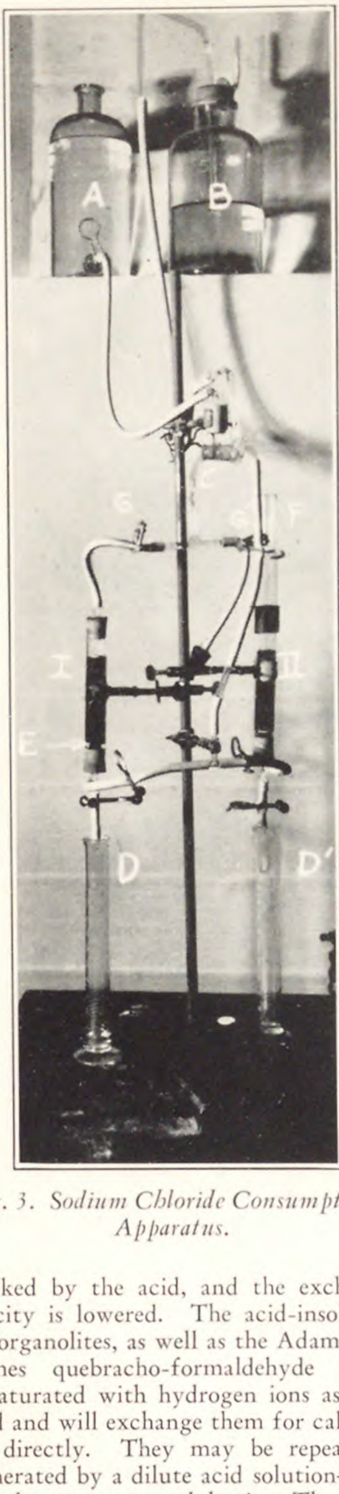


Fig. 3. Sodium Chloride Consumption Apparatus.

attacked by the acid, and the exchange capacity is lowered. The acid-insolubilized organolites, as well as the Adams and Holmes quebracho-formaldehyde resin, are saturated with hydrogen ions as prepared and will exchange them for calcium ions directly. They may be repeatedly regenerated by a dilute acid solution—for example, 5 per cent sulphuric. The effluent from such a treatment is not truly softened from the standpoint of soap consumption, since fatty acids are precipitated when soap is added; but the fact that calcium or magnesium has been removed from a hard water is easily shown by adjusting the pH to 7 (e.g., by adding dilute alkali) before titrating with soap, whereupon a zero hardness determination results. Such an acid water may presumably be used in certain instances, where metal-free water is desired, without neutralizing it. The substitution for distilled make-up water for lead storage batteries is a possibility.

An impressive application of this process is in alkalinity control and bicarbonate removal. The contributory element of zeolite-softened waters in causing caustic embrittlement in boilers is well known. When water with carbonate or temporary (bicarbonate) hardness is softened with zeolite, the effluent contains sodium carbonate or bicarbonate which hydrolyzes to sodium hydroxide under the temperatures and pressures existing in steam boilers. There are cases where sulphuric acid has been added to such waters to destroy the carbonates before adding them to the boiler; this is accomplished at the cost of extra chemical and apparatus for correct dosage and with the danger of a ruinous excess being applied. It is an easy matter to soften a water containing, say, calcium bicarbonate, and at the same time to eliminate the bicarbonate ions by using an acid-regenerated material. This is brought about by virtue of exchanging hydrogen for calcium, with the resultant formation in the treated water of carbonic acid which spontaneously decomposes into water and carbon dioxide. The latter is easily removed by aeration, and consequently the original hardness is removed and a reduction of total solids is actually accomplished.

Another field for acid regeneration is suggested by the recent papers of Cerecedo and his co-workers, who used zeolites in extracting vitamin B_1 from natural sources. Since they gave the (gel) zeolite an acid wash and carried out the procedure at about pH 4.0, organolites should be more amenable to the process.

Certain Properties of the Organolites

A comparison of three organolites and a common type of zeolite from the point of exchange capacity and salt consumption is shown in Figure 4. The salt consumption, or amount of hardness removed per pound of salt used for regenerating, is

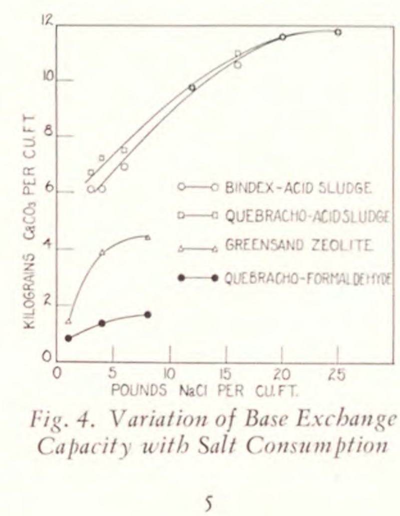


Fig. 4. Variation of Base Exchange Capacity with Salt Consumption

an important factor. The stoichiometric amount is never obtained in actual operation; therefore the amount of excess salt required affects the optimum economic working conditions profoundly.

The effect of pH was studied by repeatedly regenerating a 2x5 cm. filter bed of organolite with 200 cc. of 10 per cent sodium chloride brine, which was adjusted to various pH values with dilute hydrochloric acid or sodium hydroxide; the amount of calcium chloride solution of 400 p.p.m. hardness (adjusted to same pH value as the regenerant), which was softened to less than 5 p.p.m. hardness by the column was then determined. The data are plotted in Figure 5.

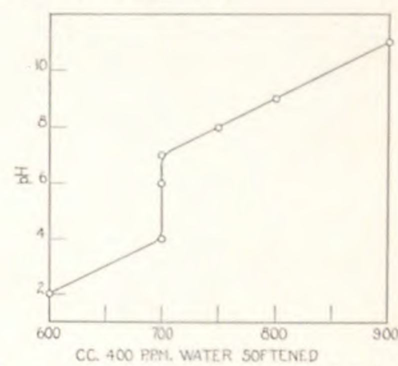


Fig. 5. Variation of Capacity of Sulphite Liquor-Acid Sludge Organolite with pH.

A possible defect of organolites is the low physical strength, since the granules are somewhat soft when wet. A quantitative estimate of resistance to abrasion has not yet been made.

Conclusion

Experiments on preparing the acid-insolubilized material on a semiplant scale substantiate the smaller scale work as does actual softening of water in a portable size unit. Although the work cannot be said to have progressed from the experimental stage, the evidence ostensibly indicates that the organolites may be of some utility in the fields of water softening and acid regeneration and also, if selectively absorptive materials are developed, for special cation absorption.

Comments by James A. Bradley, Dean of Newark College of Engineering and Associate Professor in Chemistry.

A major problem of industry is the purification of water for use in steam production. The bicarbonates and sulphates of magnesium and calcium commonly occur as mineral impurities in many waters. These produce scale in the boilers, which decreases the rate of heat transfer, lowers the efficiency of the power producing system, and eventually, if not corrected, may cause serious damage to the boilers. The remedy for such a condition

(Please turn to page 10)

A HIGH SPEED ELECTRONIC CIRCUIT BREAKER*

By HENRY JASIK, '38
Newark College of Engineering

In the power field, electronic devices are coming into wide usage to replace mechanical devices and to perform new functions. The author presents a new method of over-current protection, utilizing three electrode mercury-vapor tubes.

In the experimental circuit described thyratron tubes are used as circuit breakers. The chief advantage gained is high speed operation, since the circuit is opened in less than one cycle after the overload occurs. A secondary advantage is that no arrangements, such as oil-quenching or de-ion grids, are necessary for breaking the arc. This type of breaker may not be economically feasible in small sizes, but in the larger sizes, improved operating facilities would justify an added investment.

The use of high voltages in power transmission makes it desirable to clear line faults as quickly as possible. The fastest circuit breakers in present use are those at Boulder Dam with an operating time of three cycles.

Research was made to determine whether or not the prevention of conduction through an electronic tube would open a circuit, and, if in doing so, no arc is established. Not only did the tube accomplish these things, but it was also found that the operating time could be made to be less than one cycle. Since there was no arc, there was no need for quenching.

A thyratron FG-67 was used in the experimental device, since a mercury-vapor triode will handle larger power capacities. A high-vacuum tube of the same physical dimensions will handle 100 watts in contrast to the 2500 watts of the FG-67. The thyratron tube is essentially non-conducting until a grid voltage of the proper magnitude is applied, after which the tube conducts current, the value of which is independent of the grid voltage. In the mercury-vapor triode, once conduction has been started the grid loses control and the plate current must pass through zero in order to prevent further conduction from taking place.

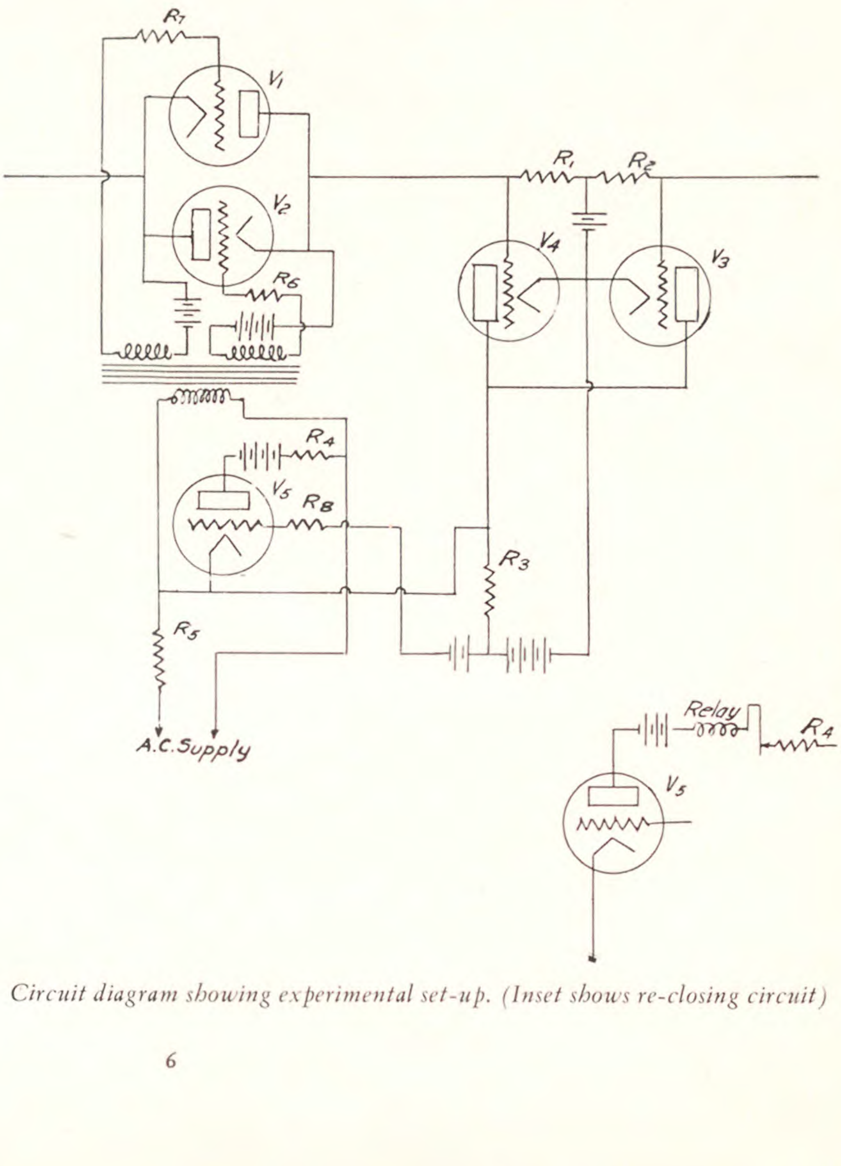
The electronic circuit breaker has two thyratrons (V_1, V_2) connected as shown in the circuit diagram (Fig. 1). Two tubes are necessary since thermionic tubes are unidirectional devices, and one is needed to prevent conduction in each direction. Normally, the proper grid voltage to start conduction is applied to each tube. When an overload occurs, a control circuit changes the grid voltage to a negative value sufficient to prevent conduction. Thus, after the control circuit has functioned, the tubes will not fire again after the plate current has passed through zero. This last fact makes it apparent that the circuit breaker is not adaptable to d rect current operation.

Since the circuit is opened when the current passes through zero, no arc is formed. The breaking time depends upon the magnitude of the overload and the point on the current cycle at which it occurs. Referring to Figure 2, if the overload occurs at A, the control circuit will operate and the grid voltage will immediately be changed to a value which prevents conduction. Since the tube is already conducting, conduction will continue until the current passes through zero at 180°. If a large overload, such as a short circuit, occurs at *B*, the tube will stop conducting at 180°, but if the overload is comparatively small, the *control* circuit will not work until 180°, and the circuit will open at 360°. These facts indicate operating times of one-quarter to three-quarters cycle.

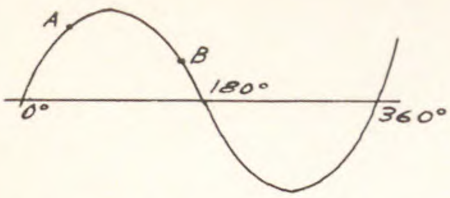
In choosing a tube for actual service, an ignitron is recommended since it can carry larger amounts of current, and can handle greater overloads, within heating limitations. It is necessary that the tube used have a low deionization time in order that reverse current flow may be prevented.

The loss in efficiency resulting from placing a tube in series with the line is not great. The tube voltage loss is about 20 volts. This would be a small factor in transmission voltages that are measured in thousands of volts.

As previously stated, an FG-67 thyratron was used for the experimental work, because of its short ionization and deionization times. The tube is also negative- or positive-fire depending upon the temperature and the anode voltage. A negative potential of 6 volts was placed on the grid, in series with a 25 volt alternating e.m.f. The 25 volt alternating e.m.f. was



Circuit diagram showing experimental set-up. (Inset shows re-closing circuit)

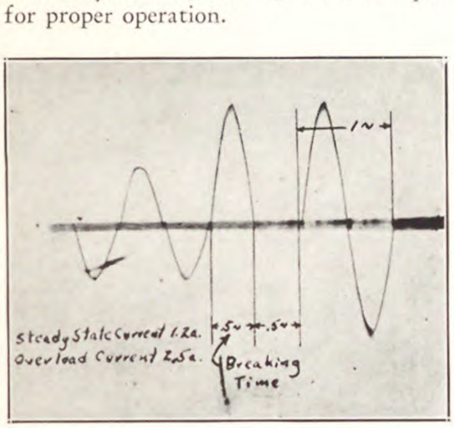


Curve showing method of determining operating times.

used to initiate conduction. The a. c. potential overcomes the negative potential of 6 volts, placing enough positive potential on the grid to insure ignition. When an overload occurs, the a. c. potential on the grids is removed, thus maintaining the 6 volt negative potential, which prevents conduction after the current passes through zero.

The control circuit is so devised that an increase in the line current removes the alternating e.m.f. on the grid. Here again electronic tubes are used to eliminate any time lag that may occur in electro-magnetic relays.

In the circuit diagram, V_1 and V_2 are the FG-67's in series with the line, V_3 and V_4 are high vacuum triodes (Type '10) and V_5 is another thyratron, FG-67. V_5 is connected across the transformer supplying the grids of V_1 and V_2. When the line current increases to an excessive value, the drop across R_1 and R_2 increases, and the current in R_3 increases. In consequence, the voltage across R_3 increases and the thyratron V_5 fires, shorting the primary of the grid voltage transformer and removing the grid voltage of V_1 and V_2. R_5 limits the short circuit current when V_5 fires. R_6, R_7, and R_8 are protective resistors, and R_4 limits the plate current of V_5. Both V_3 and V_4 are necessary if the control circuit is to operate at any part of the a. c. cycle. If one tube were used, the breaking time would be increased by one-half cycle, this being dependent upon the occurrence of the overload in the positive or the negative part of the cycle. R_1 and R_2 must be equal for proper operation.



Oscillogram showing breaking time and re-closing time with high speed relay in plate circuit of V_5

The operating current for the breaker is set by varying R_3. The breaker will remain open until the plate circuit of V_5 is opened manually or by a slow-acting relay connected as shown on the circuit diagram. The plate current of V_5 energizes this relay, so that in about 20 cycles it opens the plate circuit and the tube ceases firing, and current flows through the line again. The relay will close again, and the breaker is reset.

The oscillogram (Figure 3) shows actual test performance of the experimental breaker with a high speed relay in the plate circuit of V_5. The oscillogram shows a breaking time of .5 cycle, and a resetting of the breaker in another .5 cycle, or a total "open-close" action of the breaker within 1 cycle. Another oscillogram, not reproduced here, shows a breaking time of .73 cycle, and a resetting time of .5 cycle, or a total "open-close" action of 1.23 cycles.

The experimental data verified the theoretical predictions and demonstrated that the arrangement is practical. The author's investigation was not intended to design a breaker for actual use, but to show that electron tubes may be used in the field of over-current protection.

Comments by William Hazell, Jr., Instructor in Physics, Newark College of Engineering.

This paper was written for the required Senior Thesis in Electrical Engineering and is the result of considerable thought and research on the part of Mr. Jasik. He presented the paper in competition at a meeting of the College Branch of the A. I. E. E. and, in winning the first prize, was asked to enter the presentations of the Student Convention of the New York Section of the A. I. E. E., at which nine of the Colleges in the Metropolitan area were to be represented.

His forthright presentation showed clarity of thought, theory, and results, and was beyond reasonable doubt the best of the papers presented. Mr. Jasik's reward for this presentation was $25.00, and for winning the College competition, $10.00.

Mr. Henry Jasik graduated from Bloomfield High School in 1935 and is now a member of the Class of 1938 of the Newark College of Engineering. He is president of the Student Chapter of the American Institute of Electrical Engineers at the College and president of the Radio Club.

The electronic circuit breaker may well be adapted to uses other than high voltage transmission. It is noiseless and very definitely removes the fire hazard of oil-quenching. Its high speed action may adapt it to many other commercial uses. With the present developments of large electronic tubes, the electronic circuit breaker seems to be commercially feasible.

FIRST PRIZE TO HENRY JASIK AT STUDENT CONVENTION

By Mildred Preen, *Senior, N. C. E.*

On April 28th, over 200 students from Metropolitan engineering colleges visited the Newark College of Engineering, which this year was host to the Twelfth Annual New York Student Convention of the American Institute of Electrical Engineers.

The students started the day off with registration and the inspection of the college laboratories. The groups were then conducted to the Public Service Auditorium, where the technical session was held. It was formally opened by the Convention chairman, Mildred Preen, of N. C. E., who introduced Mr. J. Warren Johnson, also of N. C. E., as chairman of the morning session. Mr. Johnson then introduced our college President, Mr. Allan R. Cullimore, who extended for the college a welcome to the visiting students. A brief address was next presented by Mr. Jacob T. Barron, a vice-president of the Public Service Electric and Gas Company, who extended, on behalf of his company, greetings to the gathering.

Presentation of the following papers was made: A New Amplifier, by Stanley R. Rich of the City College of New York; A High Speed Electronic Circuit Breaker, by Henry Jasik of the Newark College of Engineering; Synchronous Operation of Polyphase Machines with A. C. Field Excitation, by Milton Treuhaft and Jose R. Bejarano of Columbia University; A Rate of Rise Voltmeter to Be Used in Insulating Tests, by Joseph P. Messana of the Polytechnic Institute of Brooklyn; and Circuits and Testing of the P. C. C. Car, by William R. Lacy of Pratt Institute.

Adjournment of the technical session was followed by luncheon, after which Mr. Donald C. Luce, a vice-president of Public Service, spoke briefly on the highlights of the Essex Generating Station.

At 8:00 P. M. everybody met in Duffield Hall of the Athletic Club, where dinner was served. After the dinner the evening session was called to order by Miss Preen, who introduced the toastmaster of the evening, Mr. Henry Jasik of N. C. E., chairman of the Student Council of the Metropolitan Branches. The chairman of the New York Section of A. I. E. E., Mr. A. F. Dixon, was next introduced. He spoke on the purpose of the various branches and urged that students take an interest in Institute affairs after graduation. Mr. H. H. Henline, National Secretary of the Institute, a member well-known to the group, addressed the gathering on Institute activities of the student branches.

The long-awaited decision of the judges on the best paper presented at the morn-

(Please turn to page 10)

THE "EASY FORMULAS" IN REINFORCED CONCRETE DESIGN

By Odd Albert
Assistant Professor of Structural Engineering, Newark College of Engineering

It is always of advantage for a student to be able to check his designs himself. For this purpose a different, and preferably a short cut, method is advantageous.

The method presented here, originated by this writer many years ago, will serve such purpose. It has in parts been published before, in *Civil Engineering*, April, 1931, *Engineering News-Record*, June 16, 1932, and in *Transactions of American Society of Civil Engineers* for 1937, page 411. However, the method, which originally was approximate, has been improved considerably, and has now been made mathematically correct by the introduction of the "adjustment factor." Although the writer for many years has used the method for columns in compression and bending as well as in tension and bending, this application is now presented here for the first time.

It is assumed that the reader has a working knowledge of reinforced concrete design.

Beams with Tension Steel Only

If a beam is designed to resist a certain moment (M-foot pounds), and tension steel (A_s) only can be used, then with the given stresses the effective depth (d) must be designed first, whereupon the tension steel area may be figured by the use of this depth. This is called balanced design.

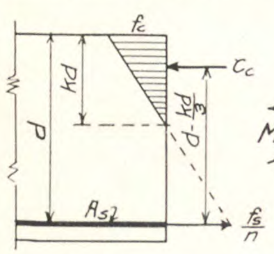


Fig. 1a

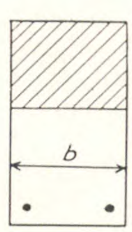


Fig. 1b

The Minimum Depth

A moment equation around the tension steel will give

$$\frac{f_c\, b\, kd}{2}\left(d - \frac{kd}{3}\right) = 12\ M \quad (1)$$

that solved for (d) gives the effective depth as

$$d^2 = \frac{72\ M}{f_c\, b\, k\, (3-k)} \quad (2)$$

so we get the "Easy Formula" for the minimum effective depth:

$$d = K_1 \sqrt{\frac{M}{b}} \quad (3)$$

where M=the bending moment in foot pounds, and K_1=a constant, depending upon the stresses only. We have

$$K_1 = \sqrt{\frac{72}{f_c\, k\, (3-k)}} \quad (4)$$

The Reinforcement

A moment around the centre of the concrete area in compression (marked C_c in figure 1, down 1/3 kd from the top), gives

$$A_s\, f_s\left(d - \frac{kd}{3}\right) = 12\ M \quad (5)$$

so we get the "Easy Formula" for the tension steel area:

$$A_s = \frac{M}{K_2\, d} \quad (6)$$

where K_2 is a constant, depending upon the stresses only. We have

$$K_2 = \frac{f_s\,(3-k)}{12 \times 3} = \frac{f_s\, j}{12} \quad (7)$$

Beams with Tension and Compression Steel

If a certain maximum depth is specified, and formula (3) gives a value of (d) larger than this maximum depth, then compression steel is required, unless the beam can be made wider.

The Tension Steel

A moment around C_c gives:

$$A_s f_s\left(d - \frac{kd}{3}\right) + A'_s f'_s\left(\frac{kd}{3} - d'\right) = 12\ M \quad (8)$$

that solved for A_s gives:

$$A_s = \frac{12\ M}{f_s\, j\, d} - \frac{A'_s f'_s (k/3 - d'/d)}{f_s\, j} \quad (9)$$

so the "Easy Formula" for the tension steel becomes:

$$A_s = A_x - A'_s\, z \quad (10)$$

where A_x=the tension steel area figured directly without considering the presence of the compression steel.

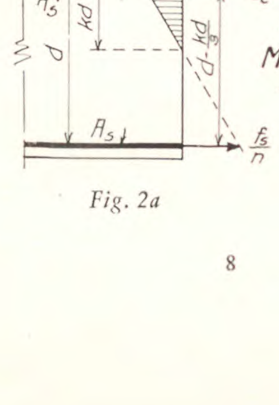


Fig. 2a

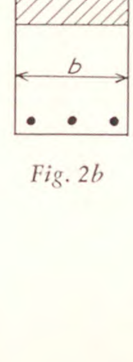


Fig. 2b

z=the adjustment factor.

Thus we get

$$A_x = \frac{12\ M}{f_s\, j\, d} = \frac{M}{K_2\, d} \quad (11)$$

which formula is identical with (6).

The Adjustment Factor z

The value of (z) is called the "adjustment factor." It is the coefficient to A'_s in expression (9). As we know that

$$f'_s = \frac{n\, f_c\,(k - d'/d)}{k} \quad (12)$$

and that $f_s = \dfrac{n\, f_c\,(1-k)}{k}$ (13)

we get $z = \dfrac{(k - d'/d)\,(k - 3d'/d)}{(1-k)\,(3-k)}$ (14)

It will be seen that (z) is very small, and that it equals zero for k=3 d'/d. It depends only upon the ratio d'/d and the value of (k), and is therefore easily figured.

The Compression Steel

A moment equation around the tension steel area gives:

$$\frac{f_c b\, kd}{2}\left(d - \frac{kd}{3}\right) + A'_s f'_s (d - d') = 12\ M \quad (15)$$

This equation can be simplified considerably. Eliminate f'_s by the use of (12), solve for A'_s, then use formulas (11) and (13) as well as the fact that

$$p = \frac{k^2}{2\, n\,(1-k)} = \frac{f_c\, k}{2\, f_s} \quad (16)$$

Therefore the "Easy Formula" for the compression steel area (A'_s) will become:

$$A'_s = K_3\,(A_x - p\, b\, d) \quad (17)$$

where

K_3=a constant, only depending upon the ratio d'/d and the value of (k). It is easily figured.

A_x=the tension steel area for the actual moment without consideration of the compression steel area. Figured from (11).

p=the steel ratio for balanced design. It can therefore be obtained from standard textbooks for given stresses, or from (16).

The value of the constant K_3 is obtained from the formula below.

Hence $K_3 = \dfrac{(3-k)\,(1-k)}{3\,(k - d'/d)\,(1 - d'/d)}$ (18)

Columns Subject to Compression and Bending with Tension Over Part of Section. Tension Steel Only

If a column with tension steel only is to be designed to resist a certain eccentric load (N), causing bending and compression, the effective depth (d) must be designed first, whereupon the tension steel may be figured by the use of this depth.

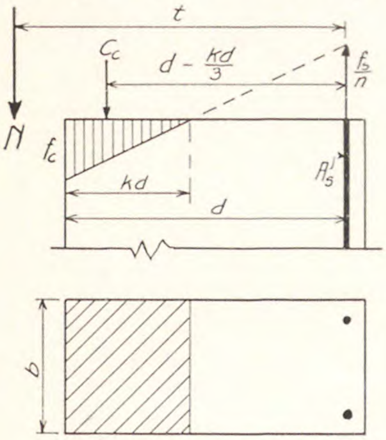


Figure 3a and 3b

The Minimum Depth

A moment equation around the tension steel area gives (compare with 1):

$$\frac{f_c b\,kd}{2}\left(d - \frac{kd}{3}\right) = N\,t = 12\,M_s \qquad (19)$$

From a comparison with (1) and (2) it will easily be seen that the "Easy Formula" for the effective depth of the column becomes

$$d = K_1 \sqrt{\frac{M_s}{b}} \qquad (20)$$

where K_1=the same constant used in the beam design.

M_s=the moment in foot pounds with reference to the tension steel area. Thus $M_s = 1/12$ N t, if t is in inches.

Therefore an ordinary beam design can be used to solve for the minimum effective depth of the column, as soon as the moment has been changed from (M) to (M_s).

The Reinforcement

A moment equation around the center of the concrete area in compression (marked C_c in figure 3, located 1/3 kd to the right from the compressed edge), gives

$$A_s f_s\left(d - \frac{kd}{3}\right) = N\left[t - \left(d - \frac{kd}{3}\right)\right] \qquad (21)$$

$$\text{or } A_s = \frac{N\,t}{f_s\,jd} - \frac{N}{f_s} \qquad (22)$$

so the "Easy Formula" for the tension steel area becomes

$$A_s = A_x - \frac{N}{f_s} \qquad (23)$$

where A_x=the tension steel area for the M_s-moment used in an ordinary beam design formula. Thus we get

$$A_x = \frac{N\,t}{f_s\,jd} = \frac{M_s}{K_2\,d} \qquad (24)$$

Therefore, by using the moment with reference to the tension steel area in foot pounds, the value of (A_x) is figured first, then deduct from this value the load divided by the allowable steel stress, and the required steel area is obtained.

Columns Subject to Compression and Bending with Tension Over Part of Section. Tension and Compression Steel Used

If formula (20) gives a larger value of (d) than can be used, then compression steel must be considered also.

The Tension Steel

For known stresses we have

$$k = \frac{n\,f_c}{n\,f_c + f_s} \qquad (25)$$

A moment equation around (C_c) gives

$$A_s f_s jd + A'_s f'_s\left(\frac{kd}{3} - d'\right) = N\left[t - \left(d - \frac{kd}{3}\right)\right] \qquad (26)$$

and by comparison with (8) and (10) it can easily be seen that the "Easy Formula" for the tension steel area will be

$$A_s = A_x - A'_s\,z - \frac{N}{f_s} \qquad (27)$$

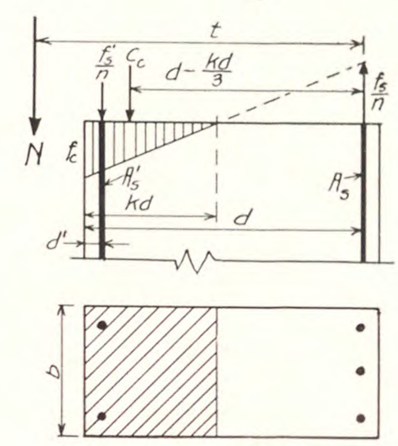


Fig. 4a and 4b

Therefore figure the tension steel area for an ordinary beam, using the moment (M_s) instead of (M), and deduct from this value the load divided with the allowable steel stress, and the tension steel area for the column is obtained.

The Compression Steel

A moment equation around the tension steel area gives

$$\frac{f_c\,b\,kd}{2}\left(d - \frac{kd}{3}\right) + A'_s f'_s (d - d') = N t = 12 M_s \qquad (28)$$

With the exception of using a moment with reference to the tension steel area instead of the centerline of the section, this expression is identical with (15). Therefore the "Easy Formula" for the compression steel area will become

$$A'_s = K_3\,(A_x - p\,b\,d) \qquad (29)$$

This formula is identical with (17) with the exception that (A_x) was figured from (24) instead of from (11).

Therefore the compression steel area in a column is figured the same way the compression steel is figured in a beam, after the moment has been changed from (M) to (M_s).

Columns in Tension and Compression with Tension Over Part of Section

It can easily be found by using (—N), that formulas (20) and (29) remain the same, while in formulas (23) and (27) the term N/f_s becomes positive. This means that the tension steel area obtained by the beam design must be increased by N/f_s.

It will be noted that the tension steel will be nearest to the load, and that M_s= Nt, where t is equal to the eccentricity minus 1/2 (d—d'). Thus we get the "Easy Formulas" for

Columns with tension steel only

$$d = K_1 \sqrt{\frac{M_s}{b}} \qquad (30)$$

$$A_s = A_x + \frac{N}{f_s} \qquad (31)$$

Columns with tension and compression steel

$$A'_s = K_3\,(A_x - p\,b\,d) \qquad (32)$$

$$A_s = A_x - A'_s\,z + \frac{N}{f_s} \qquad (33)$$

where the values of K_1 is determined by (4), A_x by (24) and K_3 by (18).

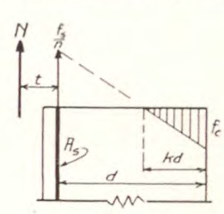


Fig. 5

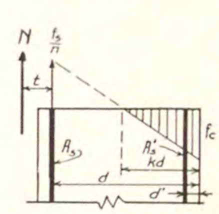


Fig. 6

The Constants

The following constants are used in the "Easy Formulas": K_1, K_2, K_3, z, k, and p. They are all easily figured out; further, k and p can be found in standard textbooks on reinforced concrete.

Suppose the following data are given: $f_s=20,000$p.s.i., $f_c=800$p.s.i., n=15, and d'/d=0.10.

Then the figurings of the constants are done as follows:

$$k=\frac{15 \times 800}{15 \times 800 + 20,000}=0.375 \text{ (Use 25)}$$

$$p=\frac{800 \times 0.375}{2 \times 20,000}=0.0075 \text{ (Use 16)}$$

$$K_1=\sqrt{\frac{72}{800 \times 0.375\ (3-0.375)}}$$

$= 0.3024$ (Use 4)

$$K_2=\frac{20,000\ (3-0.375)}{36}$$

$= 1458.3$ (Use 7)

$$K_3=\frac{(3-0.375)\ (1-0.375)}{3\,(0.375-0.1)\ (1-0.1)}$$

$= 2.210$ (Use 18)

$$z=\frac{(0.375-0.1)\ (0.375-0.3)}{(1-0.375)\ (3-0.375)}$$

$= 0.0126$ (Use 14)

Tables can easily be made up giving the values of these constants for various stresses, and values of (n) and d'/d.

Example 1. A simply supported beam is limited to 10 inches by 22 inches. The moment is 62,000 foot pounds, $f_c=800$ p.s.i., $f_s=20,000$ p.s.i., n=15, and d'=2 inches. Find the reinforcement.

For the conditions given, the constants are: $K_1=0.3024$; $K_2=1458.3$; $K_3=2.210$, p=0.0075, and z=0.0126, so

$$A_x=\frac{62,000}{1458.3 \times 20}=2.126$$

The compression steel area is obtained by the use of (17).

We get $A'_s = 2.210(2.126-0.0075 \times 10 \times 20) = 1.383$ sq. inches and the tension steel area is obtained by the use of (10).

Hence $A_s = 2.126 - 1.383 \times 0.0126 = 2.126 - 0.017 = 2.109$ sq. inches.

Attention is called to the fact that only three equations were necessary to figure the reinforcement, and to the very small influence of the compression steel on the tension steel area. If the value of (A'_s) becomes zero or less than zero, then compression steel is not necessary.

Example 2. A column 12 x 22 inches takes an eccentric load of 24,000 pounds, applied 26 inches from the center. If d'= 2 inches, and the allowable stresses are f_c= 800 p.s.i., and f_s=20,000 p.s.i., find the reinforcement.

For the conditions given, the constants are: $K_1=0.3024$; $K_2=1458.3$; $K_3=2.210$; p=0.0075 and z=0.0126.

The moment with reference to the tension steel is (M_s). We get

$M_s = 1/12 \times 24,000(26 + 9) =$ 70,000 foot pounds.

$$A_x=\frac{70,000}{1458.3 \times 20}=2.401$$

The compression steel area is obtained by the use of (29). We get

$A'_s = 2.210(2.401 - 0.0075 \times 12 \times 20) = 1.33$ sq. inches, whereupon the tension steel area is figured by the use of (27). We get

$$A_s = 2.401 - 1.33 \times 0.0126 - \frac{24,000}{20,000}$$

$= 1.184$ sq. inches.

ORGANOLITES

(Continued from page 5)

in the past has been either chemical treatment, usually by means of lime and soda ash, or filtration through a bed of zeolite. The zeolite is a sodium aluminum silicate, either natural or artificial, which removes the magnesium and calcium ions from the water, replacing them with sodium ions, and delivering for steam generation a water containing only the comparatively harmless sodium salts.

A new field for the treatment not only of hard water, but also for waters containing many other dissolved substances, is opened up by the work of Mr. Harry Burrell whose paper appears in a condensed form in this issue of NEWARK ENGINEERING NOTES. During the past few years he has worked in the laboratories of the Ellis-Foster Company in Montclair developing new kinds of ion-exchange materials. These substances, which have been named organolites, are formed by the chemical treatment of various extracts of natural products, such as the extract of quebracho or chestnut, with such things as formaldehyde or sulphuric acid or the acid-sludge by-product from petroleum refining. These were found to be in certain cases more efficient as water softening agents than the zeolites. Moreover, they possess certain added advantages, such as cheapness, low density, and resistance to waters of widely varying acidity, and may be obtained from a number of natural sources. Also they may be used not only for the exchange of a few metallic ions, but may, on suitable preparation, be used for the removal of a variety of ions from water. For instance, the gold in the wash waters of a fountain pen company has been practically entirely removed and recovered by this process.

Mr. Burrell has made this work the basis of a thesis which he is presenting this year to the Newark College of Engineering in partial fulfillment of the requirements for the chemical engineering degree. It represents two years of very intensive work on all phases of the subject. Mr. Burrell graduated from the Newark College of Engineering in 1934 with "highest academic honors in course."

ALUMNI PERSONALITIES

Alphons Puishes, Class of '29—Those of the Class of '29 or thereabouts will be interested to know that Alphons Puishes was recently made Plant Engineer for the Hamilton, Ontario, and Montreal plants of the Proctor and Gamble Company of Canada, Ltd. Mr. Puishes has been with this company since his graduation in 1929, and before his transfer to Canada, had similar duties at the Port Ivory Plant in Staten Island, N. Y.

Francis X. Lamb, Class of '30, has been in Tokió, Japan, since May, 1937, as Resident Engineer and Special Consultant for the Nippon Electric Company. He expects to remain in Japan for another year and then to return to the Weston Electric Instrument Company in Newark where he was in charge of the Commercial Engineering Department before his work took him to Japan.

Anthony H. Lamb, Class of '30, is working at present on the development and commercialization of relays and controls with the Weston Electric Instrument Company. Mr. Lamb has been with this company since his graduation from Newark Technical School in 1927. He is the co-inventor of the Weston Photronic Cell which has had many commercial applications since its inception in 1932.

Malcolm Runyon, Class of '27, is now associated as a junior partner with the consulting engineering firm of Runyon and Carey of Newark. He is also a director of the Newark District Telegraph Company. Mr. Runyon has also been devoting some time to the writing of sports stories for nationally known magazines, and some of them have appeared in *The National Sportsman*, *Hunting and Fishing*, and *The Pennsylvania Angler*.

FIRST PRIZE TO JASIK

(Continued from page 7)

ing session was now given with the announcement that Henry Jasik of Newark College of Engineering had been awarded the first prize of $25, and that Joseph P. Messana of the Polytechnic Institute of Brooklyn had been awarded the second prize of $10.

The judges were Mr. John H. Pilkington of the Consolidated Edison Company of New York, chairman; Mr. A. G. Oehler, editor, *Railway Electrical Engineer*; and Mr. R. W. King, assistant to the president of Bell Telephone Laboratories.

Among the other colleges present at the convention were New York University, Cooper Union and Rutgers University.

The main speaker of the evening, Mr. John L. O'Toole, a vice-president of the Public Service Company, then addressed the groups, speaking on the organization of his company.

Other guests of the conventions included Mr. J. F. Fairman, secretary of the New York Section of A. I. E. E., Mr. A. G. Oehler and Professor H. N. Walker of New York University, chairman of the Counselors.

WHAT OUR READERS SAY

PROFESSOR JOFFE'S INTEGRAL

To the Editor:

The magazine is excellent and has a surprising array of readable material. The writer was particularly interested in Professor Joffe's article, "The Equilibrium of a Rectangular, Horizontal Piece of Canvas Under Water Pressure," and would like to add a few words to the discussion on the final integral on page 9, first column.

This integral is, admittedly, not integrable with ordinary means but if one multiplies each side by "y," one gets, on the left side, "y.dx" and on the right hand side an integrable expression. Integrating on both sides would give as a result an explicit value of the *area* bounded by the curve. It is rather interesting to note that the value of the area connected with the curve is obtainable but not the curve itself.

Best wishes for a bright future for the new-born magazine!

Sincerely yours,
Lawrence E. Widmark,
Chief Engineer Star Electric Motor Co.
Bloomfield, N. J., May 5, 1938.

To the Editor:

The operation suggested by Mr. Lawrence E. Widmark does indeed lead to an expression for the area bounded by the curve as a function of y and the tension T. The same relationship has been obtained by Mr. E. G. Baker by considering the equilibrium of a strip of canvas of finite length.

Readers interested in the evaluation of the elliptic integral, to which Mr. Widmark refers, should consult Mr. Baker's article which will appear in the next issue of the Newark Engineering Notes.

Joseph Joffe, Ph.D.
Asst. Professor in Mechanics and Chemistry, Newark College of Engineering.
Newark, N. J., May 9, 1938.

PORTABLE VIBRATION INSTRUMENTS

Editor's Note:

The article on Great Range Portable Vibration Instruments, by Eastman Smith, appearing in our previous issue, aroused evident interest among journalists, to the extent that the editor of the *Newark Call* requested permission to send a news photographer for a picture of the Seismoscope. This then appeared in the Sunday, May 1st, paper, with a published interview.

Others have written in with interesting comments, among which we quote (in part) from L. C. Josephs, Jr., vice-president and chief engineer, Mack Manufacturing Corporation, Allentown, Pa.:

"I certainly was pleased to get the first number of the Newark Engineering Notes. With you I agree that a large part of the scientific (?) research on vibration of moving vehicles has been plain ordinary bunk.

"With unlimited time and funds it would be possible to develop satisfactory and accurate instruments to measure space-time and second derivatives in all three planes as well as in three directions of rotation. Limitations, however, are highways, methods of operation, and parts of design over which we have little control. I have always been intrigued by the third derivative of space-time. You should build 36 instruments."

Author's reply:

Mr. Josephs has long been a pioneer and leader in scientific vibration measurement. We are happy to receive his comment. The rates-of-change of acceleration, already mentioned in the article, have been measured with a microscope-Ames'-dial instrument. Direct recording would be the next valuable step in convenience.

FROM THE MAIL BAG

To the Editor:

Thank you for the copy of the Newark Engineering Notes. I think it is an excellent idea, and will do more to further our school than any previous move. . . .

Sincerely yours,
William C. Eiff,
Chemist, Merck & Co.
Elizabeth, N. J., April 30, 1938.

To the Editor:

. . . I found your column of "What Our Professors and Graduates Are Doing" very interesting. As a graduate of the Class of 1932, I am naturally interested in the activities of my fellow graduates.

Truly yours,
Edwin G. Sutcliffe,
Chief Chemist, Samuel Hird & Sons.
Lodi, N. J., May 2, 1938.

To the Editor:

. . . I think an active participation by the student body and something to stimulate the interests of the readers, such as answers to problems published in the Notes, could be incorporated. Try to keep the papers as the name suggests, a technical one, and not just an alumni paper.

Very truly yours,
Leo Kadison, '37
Tester, Crocker-Wheeler.
Newark, N. J., April 29, 1938.

To the Editor:

I was pleasantly surprised to find the new college publication . . . has a neat professional appearance and should add considerably to the prestige and popularity of the school and those associated with it . . .

I noted with unusual interest the rapid growth of the school, both as to enrollment and equipment facilities . . .

I note that the staff of the new publication is soliciting professional papers from the faculty and graduates. To show my willingness to co-operate . . . I should be glad to offer my services . . .

Very truly yours,
Wilbur J. Kupfrian,
Union Carbide and Carbon Research Laboratories, Inc.
New York, May 4, 1938.

To the Editor:

My compliments to you on your issuance of a publication so instructive and interesting.

It has long been a thought of myself and other Alumni that the use of the letters N. C. E. would ofttimes be desirable in preference to using the full name of the College when referring to it. . . .

With your publication you will have a splendid opportunity to bring this fact to the attention of the readers. As a suggestion, it might be possible to put a diagonal band across the upper left-hand corner of your outside cover and have just the letters N. C. E. on this band.

Very truly yours,
D. B. Landis,
Heating Engineer, Equitable Life Assurance Society of U. S. A.
Brooklyn, N. Y., April 29, 1938.

To the Editor:

The Newark Engineering Notes idea is a sound one, if handled in the right way.

How would it be to base the material in the Notes on things in the College's own work and in the work of its graduates? Make it practical, show where corners can be cut by application of engineering knowledge and thinking to problems in everyday practice. This could be *true of human engineering as well as the standard branches of engineering*.

Here's an idea for a column or page—a discussion of a particular piece of equipment in the College, detailing construction, applications, operation, similarity to commercial units, written to interest the reader, technical or otherwise.

John W. Moss,
Assistant Editor,
Industrial Equipment News.
Bergenfield, N. J., May 5, 1938.

To the Editor:

. . . I would at this time like to mention the fact that this first number was of excellent merit so far as the particular items discussed were concerned.

It is my sincere desire that all the succeeding numbers will be as excellent if not better than the first number.

Wishing the Notes all means of fine success, I am,

Very truly yours,
Harry A. Batley,
Production Department,
National Oil Products Co.
Dover, N. J., April 30, 1938.

A MESSAGE FROM THE EDITORS

It is a pleasure for the Editors to announce that the response from the readers of the Newark Engineering Notes has been surprisingly good.

Over seventy letters and cards of appreciation, together with suggestions and comments, have been received, and they continue to come in every day.

ABBEY PRINTING COMPANY, EAST ORANGE, N. J.

E. Schneider

—and my new cigarette is Chesterfield
Chesterfield
CIGARETTES
LIGGETT & MYERS TOBACCO CO.
CHESTERFIELD
Chesterfields are made of mild ripe tobaccos . . . rolled in pure cigarette paper . . . the best ingredients a cigarette can have
For You . . . there's MORE PLEASURE in Chesterfield's milder better taste
They Satisfy